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Natural Resources Canada
Canadian Forest Service
Ressources naturelles Canada
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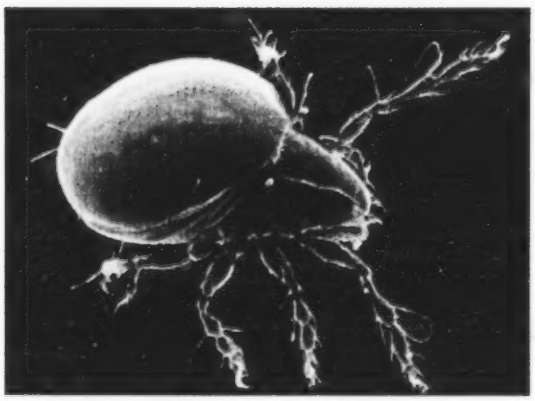
Arthropod Research

"Arthropods are the most abundant animals in forest habitats, and they contribute directly to forest productivity."

Recent work by Dr. Leland Humble, a scientist in the Forest Biodiversity Network of the Canadian Forest Service, Pacific Forestry Centre, has helped provide an update to the existing list of endemic and potentially rare and endangered arthropods in BC.

"Most arthropods haven't been extensively studied," says Humble. "In agriculture and forestry, those species that are best known are the pest species, which actually represent a small percentage of diversity."

Working with Dr. Neville Winchester and Dr. Richard Ring of the University of Victoria Biology Department, Humble has sampled at several locations on Vancouver Island to determine the arthropod diversity of ancient and regenerating forests. This information is important in that it helps determine the impact that various factors, such as non-indigenous introductions and habitat loss, may have on biological diversity in forest ecosystems. Additionally, knowledge of the abundance and distribution of individual species allows for the refinement of concepts such as rarity and endemism.



Dendrozetes *n. sp.* – *relatively abundant in hemlock branches, less abundant in* Abies *branches, and occasionally found in Hemlock lichen. This genus was previously unrecorded in North America.*

"Arthropods are the most abundant animals in forest habitats, and they contribute directly to forest productivity," notes Humble. "But when we look at their impacts, we tend to look at direct economic impacts, not ecological ones."

The introduction of exotic species is acknowledged as the second most significant threat to native diversity. As a case in point, these studies uncovered six different introduced species of rove beetles, one of which was previously known to occur only in Ontario and Quebec. Rove beetles are important as predators or fungivores in forest ecosystems. "Their presence in forests remote from the urban environments where they are first introduced demonstrates that exotics are dispersing into forest habitats. At present we don't have any idea of their roles or impacts in these habitats," says Humble.

The study examined several specific groups: the beetle mites (*Oribatida*); two families of beetles (*Coleoptera*), the rove beetles (*Staphylinidae*) and the bark and ambrosia beetles (*Scolytidae*); and the spiders (*Araneae*). Collection techniques used to generate the data sets included passive trapping (Malaise, pan and window traps), active trap systems (light and baited Lindgren funnel traps), as well as direct sampling of branches, arboreal lichens and suspended moss mats.

The beetle mites were intensively studied at two sites, with approximately 34,000 individuals recovered, encompassing 68 species. Of these species, 25 percent are named and known to science, while 75 percent are new species. And this is only a small part of the fauna of BC. In terms of determining the potential status of rare and endangered species, the study has highlighted the inadequacy of existing diversity information. Considerably more quantitative sampling across the forest landscapes of Canada is needed to document forest arthropod diversity. Only then will we get a picture of relative abundance of forest species, which will allow us to comment on rarity.

"One outcome of this research was to demonstrate how little we know about arthropod diversity in forest ecosystems, in the context of our ability to identify the species that occur there, their relative abundance, and the structure and function of arthropod communities," says Humble, who stresses the need for more research to better understand the diversity of forest arthropods and the potential impacts of forest management practices.

Dr. Winchester notes that this work has provided the evidence needed to foster the goals of sustainable management and the retention of biodiversity in these forests: "The collaboration with the Pacific Forestry Centre is invaluable and forms the essence for understanding arthropod biodiversity in ancient forests."

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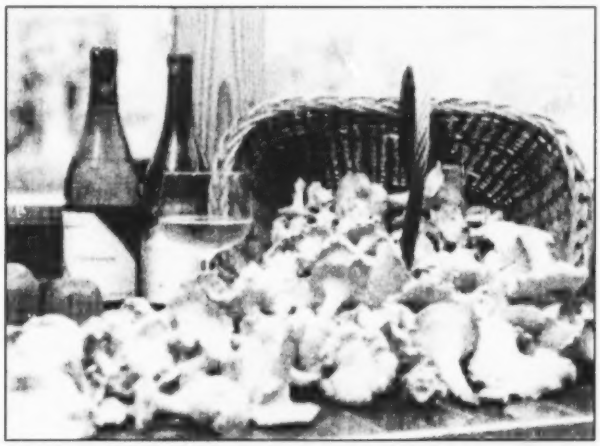
Entering the Non-Timber Forest Products Industry

"The FNFP-funded study found that there is the potential for enormous benefits to the Snuneymuxw community, and that employment in this sector of the forest industry offers community members flexibility and independence."

Every forest starts from a seed and needs a solid ground on which to grow. Likewise, to ensure success, every business needs initial funds to "get it off the ground". The First Nations Forestry Program (FNFP) is providing such "seed funding".

"This national program promotes forest-based economic development in First Nations communities," says Nello Cataldo, Program Manager, Canadian Forest Service, Pacific Forestry Centre. "For example, over the last year, FNFP contributed $10,000 towards a feasibility study on the economic viability of the Snuneymuxw First Nation establishing a non-timber botanical forestry business."

Members of the Snuneymuxw First Nation have a long history of employment in the forest industry, but this has mainly been in the local Nanaimo, BC sawmills and nearby pulp mill. Recent interest in non-timber forest products (mushrooms, berries, medicinal and culinary herbs, craft materials, and native plants) was seen as a means of decreasing the community's dependence on the traditional forest sector, while diversifying and stabilizing their economic base. The study concentrated on reviewing the market potential of a variety of non-timber forest products and services, and integrating this information with the strategic goals of the Snuneymuxw First Nation. The FNFP-funded study found that there is the potential for enormous benefits to the Snuneymuxw community, as the economic value of these products is well known and is presently increasing. Employment in this sector of the forest industry offers community members the flexibility and independence that many of them seek, while still providing a stable economic and employment base. It will also enable the elders to pass on the oral tradition and preserve the cultural and spiritual uses of these products.



Golden chantrelles are an example of a non-timber forest product.

Ultimately, the FNFP study has provided the impetus for the community to further pursue a place in the non-timber forest products industry. Utilizing the information gained through this study, and working in partnership with landowners and tenure holders in their traditional territory, business opportunities and employment can be enhanced for the entire community.

"We recognize that this will require research to fully integrate harvesting non-timber forest products with other forest activities," says Snuneymuxw Forestry Coordinator Dave Mannix. "For instance, we need to know what the effects of fertilization and thinning are on the production of salal foliage – we currently don't know what the effects of variable retention timber harvest systems will be on any of these products. Research will also be required into markets and product development."

The Snuneymuxw people feel that they can offer a level of stewardship to the land owners in their traditional territory that other harvesters of these products have not been able to offer. They have a vested interest in ensuring that the resources are harvested sustainably and respectfully, and through basic training in fire suppression and eco-conservation, they will be able to provide a unique service to the land owners.

Further details about the First Nations Forestry Program are available from the FNFP website at www.pfc.cfs.nrcan.gc.ca/main/programs/FNFP/index.html or by contacting Nello Cataldo at ncataldo@pfc.cfs.nrcan.gc.ca.

First Nations TEK in Resource Management: AI Approaches

"Only when scientific truth and the truth of Traditional Environmental Knowledge are given a more balanced recognition will policies and practices be developed that are acceptable to all stakeholders on the land."

Effective forest management today means securing not only the economic values, but also the social, environmental, cultural, aesthetic, and spiritual values of the forest for both present and future Canadians. But how does the country meet this challenge when its peoples are so varied in their ideology? For example, how can the Traditional Ecological Knowledge of First Nations which is based on a holistic approach, be represented along with science which is based on study and understanding of cause and effect relationships? The answer may lie in the application of Artificial Intelligence (AI).

"Most traditional knowledge information is presented in anecdotal form and is therefore difficult to classify and analyze," reports the Dene Cultural Institute, a non-profit organization working with the people of the Dene Nation in the Northwest Territories. "Because the information is often difficult to separate without taking it out of context, it is necessary to develop some system of cross-referencing for any system of data classification."

Traditional knowledge can guide forest management decisions.

Dr. Alan Thomson, a senior research scientist with the Landscape Management Network at the Pacific Forestry Centre, Canadian Forest Service, has been studying the possibilities of applying a range of AI approaches to forest management. He has proposed ways of representing community and environment interactions which demonstrate the differences among communities, and has developed methods for representing different codes of environmental ethics, as well as storage and analysis of anecdotal information.

"With knowledge-based approaches one may be able to predict how communities change in response to land management decisions," explains Thomson. "For example, how will opening up an area for logging affect a community and its concerns for the environment? A system which incorporates the community's codes of environmental ethics will help to answer that question."

Thomson applied a major research area of AI – elicitation, representation, and use of knowledge – to meet the challenge of including First Nations' Traditional Ecological Knowledge (TEK) to computer-based land management programs. Through the cooperation of the Nicola Tribal Association in Merritt, BC and the Nicola Valley Institute of Technology (a First Nations college), information was elicited by asking 15 members from five First Nations bands a set of questions.

"Copies of the questions were first given to the individuals so they could obtain translation if required, decide on which questions they wanted to address, and formulate their answers," says Thomson. "The questions were then asked in structured interviews conducted by a First Nations Social Studies student, and recorded."

Answers represented each community's value systems. A database was established which lists the questions (as well as the reasoning behind them, their categorization and interconnectedness), the range of responses to each question, inferences drawn from the answers, and links between the inferences and resource management. The database is also linked to a literature base which includes synopses of related publications and conference proceedings. It is available at http://www.pfc.cfs.nrcan.gc.ca/main/programs/fnfp/tek/index.html

Adds Thomson, "Only when scientific truth and the truth of Traditional Environmental Knowledge are given a more balanced recognition will policies and practices be developed that are acceptable to all stakeholders on the land."

AI may prove to be an effective means of ensuring that First Nations' environmental heritage is preserved and equally considered in forest management decision-making.

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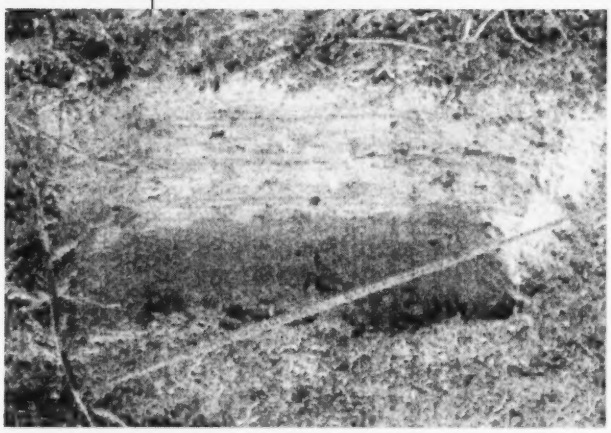
Studying Various Calcareous Soils

"Researchers encourage forest managers to recognize calcareous soils and consider the potential impacts from forest management activities."

Calcareous soils have chemical and physical properties that may have an effect on forest productivity. The Canadian Forest Service, in cooperation with the BC Ministry of Forests, has recently started studying the impacts of calcareous soils on forest productivity, as part of an overall study on calcareous soils in the Invermere Enhanced Forest Management Project.

"Found extensively in the Rocky Mountains of BC and the Alberta foothills, calcareous soils contain free calcium and magnesium carbonates," says Dr. Barbara Kishchuk, research scientist with the Canadian Forest Service, Northern Forestry Centre in Edmonton. "To date there is little information on whether these soils are less productive than acidic soils or whether they are more sensitive to disturbance resulting from harvesting operations."



Research plot looking at disturbances of calcareous soils.

Adds Dr. Doug Maynard, a research scientist with the Canadian Forest Service, Pacific Forestry Centre in Victoria, "Past studies concerning salinity toxicity indicated that carbonate may have been the primary influence that affects seedling emergence and survival. Such studies enticed us to verify whether the free calcium and magnesium carbonates found in calcareous soils affect tree establishment and growth following harvest."

Calcareous soils are typically derived from limestone or other marine deposits and have pH values exceeding 7.2, the point at which free lime occurs. The pH and carbonate content increase with the depth of calcareous soils. Eventually, carbonate minerals are dissolved and leached, resulting in gradual acidification (decrease of pH) from the surface downward. Therefore, soils developed in calcareous parent materials may have a different nutritional environment than soils that do not contain free calcium and magnesium carbonates.

"A laboratory experiment simulating five years of leaching of calcareous surface deposits showed that the forest floor pH increased from 6.8 to over 7.5," says Dr. Mike Curran, soil scientist with the BC Ministry of Forests. "Such a very large increase in alkalinity may be the result of disturbances (road construction, site preparation, stumping) which can also bring the free lime of calcareous soils closer to the surface, reducing nutrient availability from the shallow forest floor and topsoil horizons. One observation was that at the end of the test, the soil pH was still rising. This is a concern in our drier environments where it has taken about 10,000 years since glaciation to acidify as little as 10 cm of surface soil, suggesting that soil disturbance which creates subsoil deposits could have long-lived effects."

Forest productivity was found to be lower on calcareous soils in west-central Alberta, than on non-calcareous soils in the area. Increasing depth to lime was positively correlated with height and basal area in 60-year-old lodgepole pine stands in the foothills.

In the East Kootenays of BC, height and diameter were found to be greater on acidic sites than on calcareous sites. Lodgepole pine in the Invermere Enhanced Forest Management Pilot Project area are also being evaluated. Results so far suggest that the height and diameter were lower when carbonates were present in the top 40 cm of the soil, while a second trial area demonstrated no relationship between depth to carbonates and productivity.

"Areas with little rainfall can be expected to leach at a slower rate so it is not uncommon to find the calcareous material still at or near the surface," says Maynard, who is in the Effects of Forest Practices Network. "On these

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Mortality of Mountain Pine Beet

"Most moderately healthy trees could resist a few attacks, but the mountain pine beetle doesn't act alone."

The mountain pine beetles are back in BC, not that they ever really left.

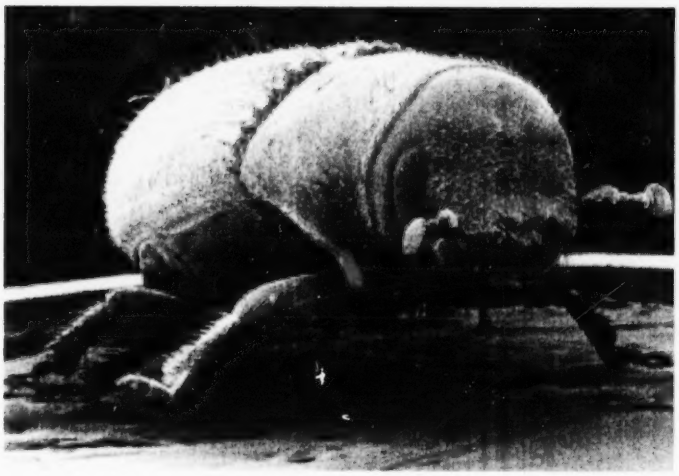
British Columbia entered another mountain pine beetle outbreak cycle this fall, with infestations of hundreds of thousands of hectares of trees in the interior. This beetle is the most destructive insect of mature pine forest in western Canada, killing millions of trees during outbreaks.

Dr. Les Safranyik, a scientist in the Effects of Forest Practices Network of the Canadian Forest Service, Pacific Forestry Centre, has been researching the mountain pine beetle for the last few decades.

"Most moderately healthy trees could resist a few attacks, but the mountain pine beetle doesn't act alone," says Safranyik, noting that as female beetles bore through the bark of the tree to establish egg galleries, they emit pheromones that attract other beetles, which facilitates a mass attack. Additionally, the mountain pine beetle carries blue-stain fungi into the tree, which are pathogenic. These fungi establish in the inner bark and sapwood of the host tree, killing live cells near the egg gallery and preventing the production of more resin, the tree's main defense against a bark beetle attack. The combined action of the beetle and the fungi interrupts the conduction of water up the tree, which eventually kills it. As well as the short-term loss of valuable timber, the beetle disrupts long-term harvest planning and forest management.

Safranyik recently studied the effects of prolonged exposure to constant low temperatures on the survival of mountain pine beetle larvae, which over-winter beneath the bark of pine trees.

The larvae rely on supercooling to avoid freezing during the winter months. The seasonal decrease in temperature is accompanied with an accumulation of glycerol and other substances in the blood of the larvae, which act as a kind of "antifreeze". Safranyik's data for the research was gathered from lodgepole pine logs that were infested with cold-hardened mountain pine beetle larvae. The logs were given a series of low temperature treatments, and then examined for brood survival. Safranyik found that unseasonably low temperatures reduced survival rates of the larvae,



Mountain pine beetle.

le Larvae at Low Temperatures

The mountain pine beetle can kill millions of trees during an outbreak.

but this effect depended on the characteristics of the tree (e.g., bark thickness and diameter).

"If we get unseasonably low temperatures in the fall or spring we should be happy, but should also continue to implement standard management practices," says Safranyik, who hopes that his findings will help focus other management methods to increase their effectiveness.

Safranyik notes that control efforts for the mountain pine beetle, which include silviculture treatments, burning and an insecticide, should be kept up each year as long as infestations prevail. Eradication of the beetle is not an option – they are native to BC, and are present in every stand within range during endemic years. And so Safranyik's extensive work, including this latest research with low temperature mortality, is important for the management of BC's forests.

"Dr. Safranyik has provided a wealth of information that forms a solid basis for those who are involved in the management of bark beetle populations," says Dr. John McLean, Acting Dean for the Department of Forestry at the University of British Columbia. "Guidelines developed by Safranyik and his colleagues help forest managers lay out long-term management plans that identify the most susceptible stands which can be removed before they are attacked and degraded by bark beetles."

Safranyik feels that we (the Canadian Forest Service, BC Ministry of Forests, and the forest industry) are better equipped to deal with the current mountain pine beetle outbreak than we were with the last one in the Chilcotin, which lasted about 15 years until the mid 1980s, when several unseasonably cold winters helped wipe it out. With continuing research from the Canadian Forest Service and diligent forest management, the effects of the mountain pine beetle can be stemmed.

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Recovering Tree Heights from Airborne Laser Scanning Data

"It is possible to use airborne laser topographic data for a cost-effective and time saving measurement of tree height."

Laser beams, extreme-value statistics and satellites – all part of the new generation of forestry technologies.

Information on tree height is essential for the calculation of forest inventories, from volume and site potential to the assessment of needs for silviculture treatments. In a move to bypass the traditional methods of measuring tree height (which are labour intensive and time consuming), Dr. Steen Magnussen of the Canadian Forest Service, Pacific Forestry Centre is studying the use of airborne laser scanning technologies to estimate forest stand height.

"The last twenty years have seen rampant development in laser scanning technology," says Magnussen, noting that modern global positioning systems enable the laser scanning by providing an instantaneous readout of where you are. "Today the technology allows you to find a height profile of any object in the path of the laser light."

Magnussen's research utilized data gathered from two intensively measured stands of Douglas Fir at Shawnigan Lake, BC. Laser scanning equipment was flown over the sites at altitudes of approximately 600 m, which in turn provided a vertical profile of the stands. But this profile represents canopy height, not tree height, because as Magnussen explains, most of the laser pulses emitted from the airborne equipment will generally hit somewhere below actual tree tops.

"In open stands, canopy height will be much lower than tree height," notes Magnussen. "For example, the average tree height in conifers is usually 1-6 m higher than the average canopy height."

The challenge lies in converting the canopy height profile into a representation of individual tree heights.

Consequently, Magnussen and his colleagues in the Landscape Management Network of the Canadian Forest Service have developed two models that describe where most canopy hits occur relative to the tree tops. If the number of trees in the stand is known or a reasonable estimate exists, a practical model is used to compute the expected number of laser beams that have hit close to a tree top. By applying extreme-value statistics to that number they are able to estimate the true value of the average or any other desired tree height in a stand to within 1 m. If the tree number is not known, a more complex model is used, and one must make additional assumptions regarding the nature of canopy penetration of the laser pulses.

"In the latter case we use complex mathematical and statistical methods to produce results that are completely at par with those produced when the stem number is known," explains Magnussen. "Overall, both models work quite well, providing close approximations of mean tree height that are as good as most ground-based data."

This comes as good news for the forest industry, which is always looking for ways to increase the efficiency of forest inventories.

"Steen's work indicates that it is possible to use airborne laser topographic data for a cost-effective and time-saving measurement of tree height," says Dr. Zhenkui Ma, a Remote Sensing Specialist with Weyerhaeuser Company in Washington. "His findings were extremely encouraging at the time when not many foresters knew how to derive tree height automatically from remote sensing technology."

Looking to the future, Magnussen notes that the field of remote sensing is still in rapid development, pointing to recent collaboration with Dr. Mike Wulder, a recently hired Canadian Forest Service scientist who will be working with new satellite-based laser scanning systems.

"The experience we gained from Steen's research with the airborne platform will help us as we transfer this technology to satellites," says Wulder, noting that the first satellite with this type of sensor will be up sometime in the year 2000.

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Dr. Wulder can be reached at mwulder@pfc.cfs.nrcan.gc.ca

Combating Tree Theft Using DNA Technology Conference

"We look forward to the day when DNA technology can be used as evidence in the courts, and the day when we get our first conviction."

Chainsaws, stolen wood and big bucks – just part of the job for a tree thief. But a recent conference hosted by the Canadian Forest Service, Pacific Forestry Centre has set the wheels in motion to introduce groundbreaking DNA evidence into the courts that could stop tree thieves in their tracks.

The Combating Tree Theft Using DNA Technology conference, held on October 5-7 of this year, represented the culmination of research in tree genotyping by Dr. Eleanor White, a research scientist at the Pacific Forestry Centre and member of the Forest Biotechnology Network. White has used DNA technology to distinguish between individual trees, which is expected to help prosecutors identify illegally harvested timber by matching stolen trees to their stumps (see Information Forestry, December 1997). The workshop brought together members of the Canadian Forest Service, the BC Ministry of Forests (BCMOF), the Royal Canadian Mounted Police (RCMP) and other scientists in the field of DNA research, giving them the chance to discuss the transfer of this new technology into the courts.

"First and foremost there is a need to bring all of the (DNA) research together to collaborate," said Cst. Stuart Wyatt of the New Westminster Police Service.

This collaboration was identified as key for the speedy transfer of the new technology, as it would eliminate time spent on overlapping research. While the basic methodology for tree genotyping is now in place, there remains the task of identifying more markers. With sufficient markers, DNA fingerprints can be used to show that a random match is highly unlikely.

All of this comes as good news for the RCMP and BCMOF field personnel who have to catch the bad guys. While they have had some luck prosecuting these criminals by physically matching the stolen logs to stumps at illegally cut sites, the thieves have found ways to render this method useless. With DNA technology waiting in the wings, the RCMP and the BCMOF will finally have the evidence they need to ensure prosecutions, and the technology itself may act as a deterrent to would-be thieves.

"In a lot of cases, DNA evidence would significantly cut down the legwork and investigation time we spend on a case," says Cpl. Hal Zech of the Forest Crimes Investigation Unit of the RCMP, who has spent his share of nights in the bush staking out illegal cut sites and chasing thieves in pick-up trucks.

Jerry Hunter, a compliance and enforcement officer with the BCMOF, notes that while there are currently seven or eight prosecutions each year for timber theft, the introduction of this new technology would be a huge asset to the Crown prosecutors.

"We look forward to the day when DNA technology can be used as evidence in the courts, and the day when we get our first conviction," said Hunter.

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Students Renée Brost and Shirley Suen stand on stump of an illegally harvested tree.

Enhancing the Effectiveness of a Virus

"Enhancing virus activity to become more effective is less intrusive on the environment than applying a chemical insecticide."

Change the slogan, "making whites whiter and brights brighter" to "making beneficial insect viruses more potent" and you may no longer attract detergent consumers, but you may get the attention of researchers trying to combat defoliating insects.

Studies first undertaken in the U.S. have indicated that optical brighteners, commonly used in detergent to make clothes look bright, not only protect beneficial, naturally occurring insect viruses against damaging ultraviolet light, but also increase the efficacy of the virus. Canadian Forest Service scientists have applied this research to the western spruce budworm, one of the most destructive forest defoliators in western North America.

"We've conducted laboratory experiments determining the effects of optical brighteners on the viral activity – the virus was isolated from the eastern spruce budworm – against the western spruce budworm," explains Dr. Imre Otvos, a senior research scientist at the Pacific Forestry Centre and member of the Pest Management Methods Network. "In order to be infected, the western spruce budworm must ingest the virus. However, this budworm has a short unprotected feeding period when it can ingest the virus, and the virus is very slow acting."

The hypothesis was that either a more potent virus or the virus combined with optical brighteners would result in greater and quicker western spruce budworm mortality.

Dr. Shiyou Li, research scientist at the Canadian Forest Service, Atlantic Forestry Centre, worked on this research with Dr. Otvos while he was at the Pacific Forestry Centre. "We have tested nine different optical brighteners and found that five of these were effective in enhancing the effectiveness of the virus," adds Li, who is also a member of the Pest Management Methods Network. "We've found that optical brighteners enhanced the effectiveness of viral activity by 2- to 4-fold."

In the 1980s, field experiments in BC indicated that aerial applications of the virus killed only 50-60 percent of the larvae. If the increase in the effectiveness of the virus by the addition of optical brighteners observed by Otvos and Li in the lab can be duplicated in the field, then larval mortality will be increased to a more economically acceptable level of about 90 percent. Despite its potential to defoliate large numbers of trees, the goal is not to eradicate the western spruce budworm population, as it is a native component of the BC forest ecosystem.

According to Otvos, the next step will be to apply this research under field conditions in a small, pilot experiment to determine the effects of using optical brighteners to enhance the effectiveness of the virus against the western spruce budworm while the insect is in its natural environment. The virus is host-specific and therefore will not affect insects other than the budworm. And because it is a naturally occurring pathogen, enhancing the effectiveness of the virus is less intrusive on the environment than applying a chemical insecticide.

This Canadian Forest Service research was also funded in part by Forest Renewal BC.

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Severe defoliation caused by western spruce budworm.

Glossary

Terminology Used in this Issue

Arthropod – a phylum (*Arthropoda*) of invertebrate animals (including insects, spiders, mites, millipedes, crustaceans etc.) that have a segmented body grouped into two or three distinct regions and paired segmented appendages, a chitinous exoskeleton molted at intervals, and nervous system consisting of a dorsal anterior brain or ganglion connected to a ventral chain of ganglia

Endemic – restricted or peculiar to a locality or region

First Nations Forestry Program (FNFP) – A national program designed to improve economic conditions in status Indian communities with full consideration of the principles of sustainable forest management

Pheromone – a chemical substance that is produced by an animal and serves especially as a stimulus to other individuals of the same species for one or more behavioral responses

Recent Publications

The State of Canada's Forests 1998 - 1999
Anon. Natural Resources Canada, Canadian Forest Service, Ottawa ON. (1999).

L'état des forêts au Canada 1998 - 1999
Anon. Ressources naturelles Canada. Service canadien des forêts, Ottawa ON. (1999).

A population dynamics model for the mountain pine beetle, *Dendroctonus ponderosae* Hopk. (Coleoptera: Scolytidae)
Safranyik, L.; Barclay, H.; Thomson, A. Riel, W.G. Information Report BC-X-386. Canadian Forest Service, Pacific Forestry Centre, Victoria, BC. 41 p. (1999).

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Stockburger, K.A.; Mitchell, A.K. Information Report BC-X-383. Canadian Forest Service, Pacific Forestry Centre, Victoria, BC. 30 p. (1999).

The Bridge. Newsletter - November 1999
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Eight-spined spruce bark beetle - *Ips typographus*
Humphreys, N.; Allen, E. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Exotic Forest Pest Advisory No. 3. 4 p. (1999).

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Sols calcaires
Kishchuk, B.; Maynard, D.; Curran, M. Notes de Transfert Technologique. Numéro 15. Service canadien des forêts, Centre de foresterie du Pacifique. (1999).

To order publications on-line, visit the Pacific Forestry Centre Bookstore at **http://bookstore.pfc.cfs.nrcan.gc.ca**. Search our catalog of thousands of forestry publications. Order copies quickly and easily using a virtual "shopping cart".

Upcoming Events

The Role of Boreal Forests and Forestry in the Global Carbon Budget
May 8-12, 2000
Edmonton, Alberta, Canada
The Role of Boreal Forests and Forestry in the Global Carbon Budget is an international conference focussing on the current scientific understanding of forest carbon dynamics in the circumpolar boreal region. For more information, check the website at www.nofc.forestry.ca/carbon or contact the Carbon Conference Coordinator by fax at: (780) 435-7356 or email carbon@nofc.forestry.ca

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sites, calcareous material may be present from the surface of the mineral soil through the rooting zone to subsoil horizons."

Curran notes that other components of the calcareous soils project include evaluating Armillaria root rot treatments, soil disturbance rehabilitation, and the effects of compaction and topsoil removal on these soils.

The researchers encourage forest managers to recognize calcareous soils and consider the potential impacts from forest management activities. A simple test to determine the presence of calcareous soils is to place a few drops of diluted hydrochloric acid (10% HCl) on the soil. If an effervescence, or "fizz", occurs, the soil can be considered calcareous.

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